On the Characteristics of the Primary Groups of the Class of Mammals. By Dr. Theodore Gill.

At the last meeting of the Association, the author made a communication on the classification of mammals, based on facts in part already become the common property of science, and in part hitherto unpublished. An abstract giving the conclusions arrived at has been published in the American Naturalist and in the Proceedings of the Association. Continued researches into the same subject have confirmed the propriety of the ordinal groups and the limits then admitted, but have necessitated a different combination of those groups.

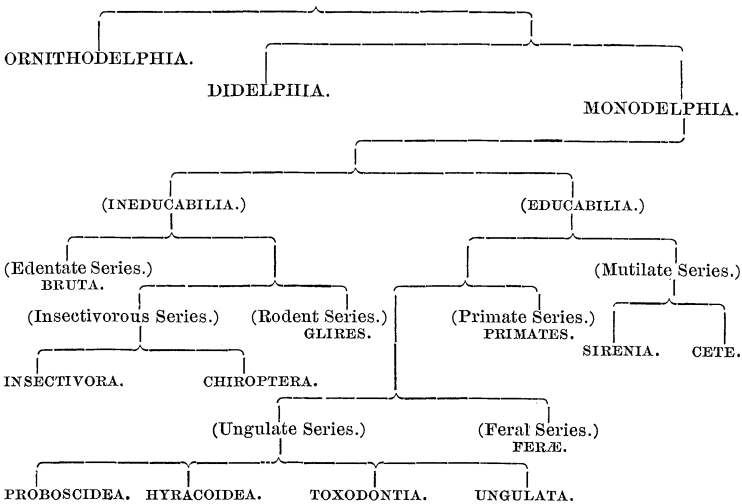
The divisions into sub-classes first solidly established by Huxley are retained.

The Placental or Monodelphian mammals are with more propriety combinable into two major groups which correspond; on the one hand, to the Educabilia of Bonaparte, the combined Archencephala and Gyrencephala of Owen, and the combined Archonts and Megasthenes of Dana; and on the other hand, to the Ineducabilia of Bonaparte, the Micrencephala of Owen and the Microsthenes of Dana. The characters hitherto used to distinguish those groups are however either vague and difficult of application, not characteristic, or generally regarded as erroneous. But positive and easily recognizable characters appear to exist in the brain which confirm those groups, but which have not hitherto been regarded, at least in respect to their systematic application.

There has also always existed cause to deplore the insufficiency of the characters assigned in the diagnoses of some of the orders of mammals. After an attentive study of most of the known forms, the author believes that he has succeeded in finding characters which at the same time confirm the groups already recognized and supplement the teleological characters (sometimes of doubtful application or entirely failing) by morphological characters of more constancy. The revised diagnoses of the orders and other primary divisions are submitted in advance of a work now being printed by the Smithsonian Institution; that work will give the characters, contrasted in dichotomous tables, of all the groups of mammals as low as subfamilies and lists of the genera, recent and extinct. While the author has been dependent, for the most part,

on the collections of the Smithsonian Institution for his investigations, he has also visited the museums of the Academy of Natural Sciences of Philadelphia, the Peabody Academy of Science of Salem, the Boston Society of Natural History, and the Museum of Comparative Zoology at Cambridge.

The relations of the several primary groups of the class may be more readily understood from a glance at the subjoined table, which will also serve as a genealogical table for those who accept the doctrine of evolution. The more generalized forms — and therefore the quasi-eldest — are represented by the left branches. It may not be entirely superfluous to remark that adaptive special modifications must be subordinated to morphological in every case: it will therefore be understood that although the Cetacean is, in a teleological sense, the most specialized form of mammals, it is a divergent from the same common stock as the Carnivores and other Educabilia, and must be contrasted morphologically with them alone and not with the rest of the mammals; the bat, another extremely specialized form, is in like manner a derivative from the same common stock as the Insectivores, and therefore to be contrasted with them alone.



CLASS MAMMALIA.

Abranchiate Vertebrates with a brain whose cerebral hemispheres are more or less connected (and in nearly inverse ratio) by an anterior com-

missure, and a superior transverse commissure (corpus callosum); the latter more or less roofing in the ventricles: the lungs and heart in the thorax and separated from the abdominal viscera by a muscular diaphragm: aorta single and reflected over the left bronchus: blood with red non-nucleated blood-corpuscles undergoing a complete circulation; entirely received and transmitted by the right half of the quadrilocular heart to the lungs for aeration (and thus warmed), and afterwards returned by the other half through the system. Skull with two condyles, chiefly developed on the exoccipital elements (one on each side of the foramen magnum): with the malleus and incus superadded as specialized auditory ossicles: and the lower jaw (composed of a pair of simple rami) articulated directly by convex condyles with the squamosal bones. Dermal appendages developed as hairs. Viviparous: fœtus developed from a minute egg: young nourished after birth by a fluid (milk) secreted in peculiar glands (mammary) by the mother.

SUB-CLASS MONODELPHIA.

Brain with the cerebral hemispheres connected by a more or less well-developed corpus callosum composed of a body as well as a folded psalterial portion, and a reduced anterior commissure; with a well developed septum. Sternum with no element in front of the manubrium or presternum. Coracoid not connected with the sternum, but early anchylosed with and developed as a simple process of the scapula. Oviducts debouching into a single vagina. Testes variable in position, but the vasa deferentia open directly or indirectly into a distinct and complete uretha, (and not into a cloacal cavity). Ureters discharge directly into the bladder the renal secretion, which thence passes into the uretha. Mammary glands with well developed nipples. Young retained within the womb till of considerable size and nearly perfect development, and deriving its nourishment from the mother through the intervention of a "placenta" (developed from the allantois) till birth. Scrotum never in front of penis.

Super-Order Educabilia.

Brain with a relatively large cerebrum, behind overlapping much or all of the cerebellum, and in front much or all of the olfactory lobes; corpus callosum (attypically) continued horizontally backwards to or beyond the vertical of the hippocampal sulcus, developing in front a well-defined recurved rostrum.

(*EDUCABILIA QUADRIPEDIA.*)

Posterior members and pelvis well developed. Periotic and tympanic bones articulated with the squamosal.

(*Primate Series.*)

I. ORDER PRIMATES.

Members almost or entirely exserted outside of the common abdominal integument. Digits with corneous appendages developed as claws (i. e.

compressed) or, attypically, as nails (i. e. depressed). First digit (great toe) of hind foot (pes) enlarged, opposable to the others (in man, resuming parallelism with them), always furnished with a nail. Clavicles completely developed. Brain with a well-developed calcarine sulcus, giving rise to a hippocampus minor within the posterior cornu of the ventricle by which the posterior lobe of the cerebrum is traversed. Teeth of three kinds (canines of second set exceptionally atrophied), all encased in enamel; molars rooted. Incisors four in each jaw: etypically, two — or all — in upper jaw suppressed. Placenta deciduate, discoidal.

Contains eight families, representing two sub-orders: ANTHROPOIDEA, with five families, and LEMUROIDEA with three families.

(*Feral Series.*)

II. ORDER FERÆ.

Legs with the proximal joints (humerus and femur) more or less inclosed in the common abdominal integumen. Digits with corneous appendages developed as claws: first digit of hind foot attypically reduced or atrophied: etypically hypertrophied (e. g. *Pinnipedia*). Clavicles none, or rudimentary. Brain with no calcarine sulcus. Teeth of three kinds, all encased with enamel: canines specialized and robust; molars attypically adapted for carnivorous diet, one $(\frac{\text{P. m.}4}{\text{m.}1})$ or more in each jaw being sectorial, followed by tubercular ones. Incisors archetypically six in each jaw, exceptionally two or more suppressed. Placenta deciduate, zonary. Scaphoid and lunar consolidated into one bone.

Contains twenty families, representing two sub-orders: CARNIVORA or FISSIPEDIA, with seventeen families, four of which are extinct, and PINNIPEDIA with three families.

(*Ungulate Series.*)

Legs with the proximal joints more or less inclosed in the common abdominal integuments. Digits with corneous appendages developed as hoofs. Clavicles entirely absent. Teeth of three kinds (canines and incisors of second set exceptionally in part undeveloped), all encased in enamel: molars attypically with grinding surfaces. Scaphoid and lunar separate.

III. ORDER UNGULATA.

Incisors (archetypically $\frac{6}{6}$: often, especially in the upper jaw, reduced in number or wholly suppressed: implanted by simple roots) with incisorial crowns. Feet with inferior (or, rather, posterior) surfaces with a hairy skin continuous with the rest of the integument; carpal bones in two interlocking rows; cuneiform, narrow, and affording a diminished surface of attachment forwards for the ulna (which is retrorse beside the radius); unciform and lunar articulating with each other and interposed between the cuneiform and magnum: hind foot with the astragalus at its anterior portion scarcely deflected inwards, articulating more or less with the cuboid as well as navicular: toes (not more than four — d 2 to d 5 — completely developed) with terminal joints encased in thick hoofs. Placenta non-deciduate (diffuse or cotyledonary).

Contains twenty-nine families, representing two sub-orders; ARTIODACTYLI, with nineteen families, of which eight are extinct, and PERISSODACTYLI with ten families, of which seven are extinct.

IV. ORDER TOXODONTIA.

Incisors ($\frac{6}{6}$ or $\frac{4}{6}$, variable as to insertion), with incisorial crowns. Feet? carpal bones? hind foot with the astragalus at its anterior portion inclined obliquely inwards, articulating in front only with the navicular; (calcaneum with an extensive upwards surface for the articulation of the fibula, and with a large lateral process articulating in front with the astragalus. Molars of upper jaw, broad and extending into an externo-anterior angle; of lower jaw, narrow and continuous, in a uniform row).

Contains two families, both of which are extinct.

V. ORDER HYRACOIDEA.

Incisors ($\frac{4}{4}$) of upper jaw next to symphysis (with persistent pulps) long and curved; those of lower jaw straight and normal. Feet with inferior surfaces furnished with pads (as in Rodents and Carnivores): carpal bones in two interlocking rows: cuneiform extending inwards (and articulating with magnum), and affording an enlarged surface of attachment forwards for the ulna (which is antrorsely twisted); unciform and lunar separated by the interposition of the cuneiform and magnum: hind foot with the astragalus at its anterior portion extended, and, as a whole, much deflected inwards, articulating in front only with the navicular; toes (four to the front feet, three to the hind) with terminal phalanges encased in hoofs (inner nail of hind foot curved). Placenta deciduate, zonary.

Contains one family.

VI. ORDER PROBOSCIDEA.

Incisors ($\frac{2}{0}$, or, in extinct forms, $\frac{2}{2}$ or $\frac{0}{2}$, renewed from persistent pulps,) developed as long tusks curved outwards. Feet with palmar and plantar surfaces invested in extended pad-like integuments, which also underlie the toes: carpal bones in two regular (not interlocking) rows, broad and short; cuneiform extended inwards — broad, and furnishing an enlarged surface of attachment forwards for the ulna (which is antrorsely produced). Unciform directly in front of cuneiform, and magnum directly in front of lunar: hind foot with the astragalus at its anterior portion very short (convex,) and not deflected inwards, articulating in front only with the navicular: toes (five to each foot, in known forms,) encased in broad shallow hoofs. Placenta deciduate, zonary. Snout produced into a very long proboscis. Legs mostly exserted outside the abdominal integument; and with the proximal and succeeding joints extensible in the same line.

Contains two families, one of which is extinct.

(*EDUCABILIA MUTILATA.*)

(*Mutilate Series.*)

Posterior members and pelvis more or less completely atrophied; the

form of the body being fish-like, furnished with a horizontal tail, and specialized for progression in the water. Periotic and tympanic bones anchylosed together, but not with the squamosal.

VII. ORDER SIRENIA.

Brain narrow. Skull with the foramen magnum posterior, directed somewhat downwards: supra-occipital nearly vertical and not extending forwards, the parietals meeting and interposed between it and the frontal. Periotic with a posterior irregularly rounded part; tympanic annuliform. Lower jaw with well-developed ascending rami and normal transverse condyles and coronoid processes. Lateral teeth molar, and adapted to trituration of herbage. Neck moderate; second cervical vertebra with an odontoid process. Anterior members moderately long, flexed at the elbow; with carpal bones and phalanges directly articulated with the adjoining ones; and with normal digits. Mammæ two, pectoral. Heart deeply fissured between the ventricles.

Contains four families one of which is certainly, and another probably, extinct.

VIII. ORDER CETE.

Brain broad. Skull with the foramen magnum entirely posterior, directed somewhat upwards: supra-occipital very large, sloping forwards, and (attypically) extending forwards over or between the frontals. Periotic attenuated backwards; tympanic solid, entire. Lower jaw with no ascending ramus, with its narrow condyles at the posterior extremities or angles of the rami, and with only rudimentary coronoid processes. Teeth (lateral) conic or compressed. Neck attypically very short; second cervical vertebra with no odontoid process. Anterior members (attypically) abbreviated, extended backwards in a continuous line; with carpal bones and phalanges often separated by cartilage; and with the second digit composed of more than three phalanges. Mammæ two, inguinal.

Contains ten families, representing three sub-orders; ZEUGLODONTIA with two families, both extinct; DENTICETE with six families, one of which is extinct; and MYSTICETE with two families.

Super-Order Ineducabilia.

Brain with a relatively small cerebrum, leaving behind much of the cerebellum exposed, and in front much of the olfactory lobes: corpus callosum extending more or less obliquely upwards and terminating before the vertical of the hippocampal sulcus, with no well defined rostrum in front.

(*Insectivorous Series.*)

Teeth encased in enamel: incisors (very variable as to number) without persistent pulps: canines present (but sometimes modified in form): molars attypically with pointed cusps. Lower jaw with condyles transverse, received into special condyloid sockets. Placenta discoidal deciduate.

IX. ORDER CHIROPTERA.

Anterior members adapted for flight: the ulna and radius being united, and the metacarpal bones and phalanges — 2d to 5th — much elongated; the whole sustaining a very thin leathery skin arising from the sides of the body, and extending backwards on the hind members, down to their tarsi. Mammæ pectoral.

Contains nine families representing two sub-orders; FRUGIVORA with one family, and INSECTIVORA with eight families.

X. ORDER INSECTIVORA.

Anterior as well as posterior members adapted for progression on land: the ulna and radius entirely or partly separated: metacarpal bones and phalanges normally developed. Mammæ abdominal.

Contains ten families referable to two sub-orders; DERMAPTERA, with one family, and GRADIENTIA, with nine families, one of which is extinct.

(Rodent Series.)

XI. ORDER GLIRES.

Teeth encased in enamel: incisors ($\frac{2}{2}$; exceptionally, also two supplementary posterior teeth,) continually reproduced from persistent pulps, and growing in a circular direction: canines null: molars attypically with ridged surfaces. Lower jaw with condyles longitudinal, and not received in special condyloid cavities, but gliding freely backwards and forwards. Members and feet ambulatorial. Placenta discoidal deciduate.

Contains sixteen families, representing two sub-orders: SIMPLICIDENTATI, with fourteen families, and DUPLICIDENTATI, with two families.

(Edentate Series).

XII. ORDER BRUTA.

Teeth (when developed) not encased in enamel: incisors typically absent (lateral present in Dasypus): molars variable: members and feet ambulatorial (modified often for grasping and digging). Placenta variable (discoidal deciduate in *Orycteropodidæ* and *Dasypodidæ;* diffuse deciduate in *Manididæ;* and coyledonous non-deciduate? in *Bradypodidæ*).

Contains nine families, representing five sub-orders. VERMILINGUIA, with one family; SQUAMATA, with one family; TODIENTIA, with one family; TORDIGRADA, with two families, one of which is extinct, and DORICATA, with three families, one of which is extinct; also one extinct family of undetermined affinities.

SUB-CLASS DIDELPHIA.

Brain with the cerebral hemispheres chiefly connected by a well-developed anterior commissure, the corpus callosum being rudimentary, and with a moderately developed septum. Sternum with no element in front of the manubrium. Coracoid not connected with the sternum, but early anchylosed with and developed as a simple process of the scapula. Oviducts debouching into separate vaginas. Testes chiefly abdominal; vasa

deferentia opening into a distinct urethra. Ureters discharge directly into the bladder the renal secretion, which thence passes into the urethra. Mammary glands with well developed nipples. Young born when of very small size and imperfect development; never connected by a placenta with the mother, but attached by her to the nipple when born, from which the milk is forced by herself into the mouth of the young. Scrotum in front of penis.

XIII. ORDER MARSUPIALIA.

Only order of the sub-class. Contains thirteen families, referable to four sub-orders: RHIZOPHAGA, with one family; SYNDACTYLI, with seven families, two of which are extinct; SARCOPHAGA, with two families; and CHIROPODA with one family; also two extinct families of doubtful affinities.

SUB-CLASS ORNITHODELPHIA.

Brain with the cerebral hemispheres chiefly connected by a well developed anterior commissure, the corpus callosum being very rudimentary, and with no defined psalterial fibres; with the septum very much reduced in size. (Flower.) Sternum with a peculiar T-shaped bone (the episternum or interclavicle) in advance of the manubrium or presternum. Coracoid extending from the clavicle to the sternum, and only towards maturity anchylosed with the scapula. The oviducts, enlarged below into uterine pouches, but opening separately from one another, as in oviparous vertebrates, debouch, not into a distinct vagina, but into a cloacal chamber, common to the urinary and genital products, and to the fæces. Testes abdominal in position throughout life, and the vasa deferentia open into the cloaca, and not into a distinct urethral passage. Ureters pour the renal secretion, not into the bladder, which is connected with the upper extremity of the cloaca, but into the latter cavity itself. Mammary glands with no distinct nipples. (Huxley.)

XIV. ORDER MONOTREMATA.

Only order of the sub-class. Contains two families.

ON THE RELATIONS OF ANOMIA.—BY PROF. EDWARD S. MORSE.

THIS peculiar genus of Lamellibranch mollusks included also Terebratula according to the early writers on the subject. Misled by external characters, Linnæus, Lamarck and others believed these two forms closely related. While not the slightest ground existed for bringing them together, yet the mere fact of these two animals being enclosed within a limy shell composed of two pieces, held to the rock by a process which passed out through that element of the shell which was below, was sufficient proof of their kinship, at least to those who were ready to judge everything